

A4 monitor

a compact high-end loudspeaker

The A4 monitor is an exclusive design for home constructors and is of a quality that should approach the limits of what is currently possible with a two-way system. It is certainly one of the most impressive small loudspeakers that we have ever listened to. Audio enthusiasts with space problems in their home will find the design ideal for their requirements. The name of the design is derived from the dimensions of the front panel which are the same as those of A4 paper. The A4 has only one drawback: it is not cheap!



Some parameters

◆ Type of enclosure	Bass reflex
◆ Net volume	About 9 litres
◆ Dimensions	298×210×269 mm (11.73×8.27×10.59 in) (h×w×d)
◆ Drive units	Bass/mid-range: Scan-Speak Type 15W8530K00 (15 cm) High-frequency: Scan-Speak Type D2904/980000 (28 mm)
◆ Sensitivity	85.5 dB/W at 1 metre
◆ Nominal impedance	8 Ω
◆ Power rating	60 W
◆ Estimated cost (per loudspeaker, excl enclosure)	About £250

Design by R Smulders

INTRODUCTION

For all sorts of reason, domestic loudspeakers should be as small and unobtrusive as possible. However, the fundamental efficiency equation

$$\eta_0 = k_n f_3^3 V_B$$

(where $k_n = 2 \times 10^{-6}$ for a well-designed bass reflex enclosure, and 10^{-6} for a good-quality sealed enclosure, f_3 is the -3 dB low-frequency rolloff point, and V_B is the volume of the enclosure in litres), shows that any alteration of volume or cutoff frequency affects the efficiency. So, if the volume of the enclosure is reduced, either the low-frequency range must be curtailed or a lower efficiency must be accepted. In these days of high power amplifiers, lowering the efficiency is no problem, so that to a certain degree the bandwidth can be maintained in a small enclosure. Clearly, this cannot be continued *ad infinitum* owing to the thermal power handling limit of the speech coil and the increasing non-linearity of the reflex port and/or air volume.

In the A4 Monitor the designer has succeeded, by careful design, to arrive at the correct compromise of two seemingly incompatible properties: small dimensions and high quality of sound reproduction. The bass reflex tuning is very well calculated, the sturdy enclosure is free of any resonances, the cross-over filter is perfectly tuned, and, last but not least, the A4 uses two brand-new high-end drivers from the Danish manufacturer Scan-Speak.

The result of the meticulous design is that the quality of the A4 is very close to that of much larger units and provides a detailed and realistic sound with a surprising bass performance. In fact, during tests, many listeners (who could not see the loudspeakers) thought they were listening to much larger ones.

TWO-WAY SYSTEM

The times when a two-way system was referred to somewhat disparagingly or even derisively as 'only a two-way system' are long gone. After the short-lived euphoria of four- or five-way systems had died down, many high-end manufacturers happily reverted to two- and three-way systems. An answer to the perennial question of what is better, a two-way or a three-way system, can only be given when all circumstances are known. Even then, it should be borne in mind that any multi-way system is a compromise. The ideal solution would be a loudspeaker with a single driver providing a straight phase and frequency response over the entire audio range from 20 Hz to 20 kHz.

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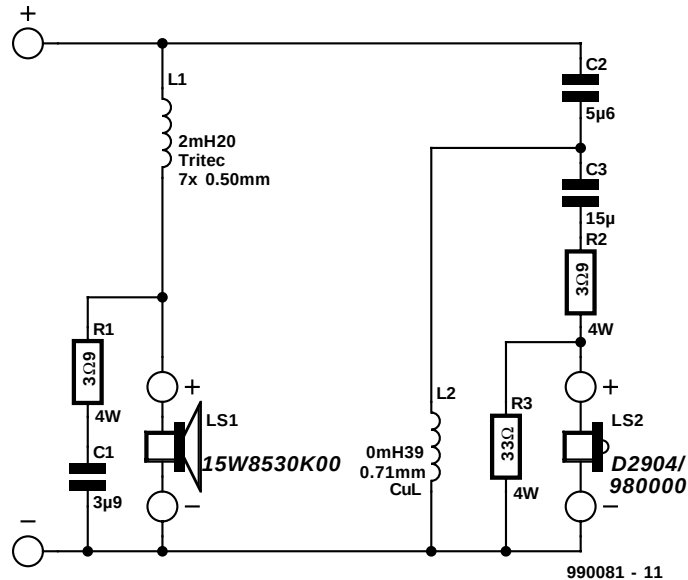


Figure 1. The crossover filter consists of two sections: a 1st-order low-pass for the bass/mid-range driver, and a 3rd-order high-pass for the tweeter.

Since such drive units do not (yet) exist, the audio range is perforce reproduced by two or three drivers. At the cross-over frequencies of these units inevitable errors arise which are not easily obviated or remedied. It is therefore the aim of most manufacturers to limit the number of crossover frequencies, that is, the number of drivers.

The choice of the number of drivers in a multi-way system is determined by the required reproduction. If, for instance, a very high sound pressure level over the bass range is required, a woofer with a diameter of not less than 25 cm is needed. Unfortunately, units with such a large diameter have a tendency of causing bunching at the low middle frequencies. This makes them unsuitable for use at frequencies above about 1 kHz. This precludes their use in a two-way system, because there are no tweeters that cover the frequency range 1–20 kHz. Dome tweeters with a diameter of 28 mm usually cannot reliably handle frequencies below 2–3 kHz, while 19 mm models have a lower limit of 4–5 kHz.

If sound pressure levels below 100 dB in the bass range are acceptable, a smaller woofer may be used. However, since an SPL (sound pressure level) of at least 100 dB is needed to do justice to modest level bass sounds, this normally rules out frequency responses extending below 50 Hz. However, the bass/mid-range driver specified for the A4 is capable of producing an adequate acoustic output at low frequencies.

Bass drivers with a diameter of 13–17 cm are perfectly capable of reliably reproducing frequencies up to

2–3 kHz, which makes the use of a mid-range driver unnecessary. The design of some of these smaller woofers is such that they can reproduce bass frequencies very satisfactorily in a relatively small enclosure. The unit used in the A4 monitor is a good example of one.

CROSSOVER FILTER

The passive crossover filter ensures that the two drivers are provided with the section of the frequency range intended for them. It is carefully designed to match the properties of the drivers and the enclosure. Constructors are advised not to use a different filter (or drive units) since this would result in a highly unsatisfactory loudspeaker.

The circuit diagram in **Figure 1** shows that the design of the filter is straightforward. The 1st-order low-pass section (response rolls off at 6 dB/octave) for the bass/mid-range driver consists primarily of inductor L1. Network R1-C1 corrects the rising impedance of the driver at high frequencies; without it the filter would not function correctly. Since the internal resistance of the inductor must be as low as feasible, it consists of seven turns of 0.5 mm diameter copper wire, which gives an effective wire thickness of 1.5 mm. This construction results in an internal resistance of only 0.52 Ω. Another advantage of using twisted wire is a sharp reduction of the skin effect.

The 3rd-order high-pass section (response rolls off at 18 dB/octave), consists of capacitors C2 and C3, and inductor L2. Potential divider R2-R3 attenuates the power applied to the

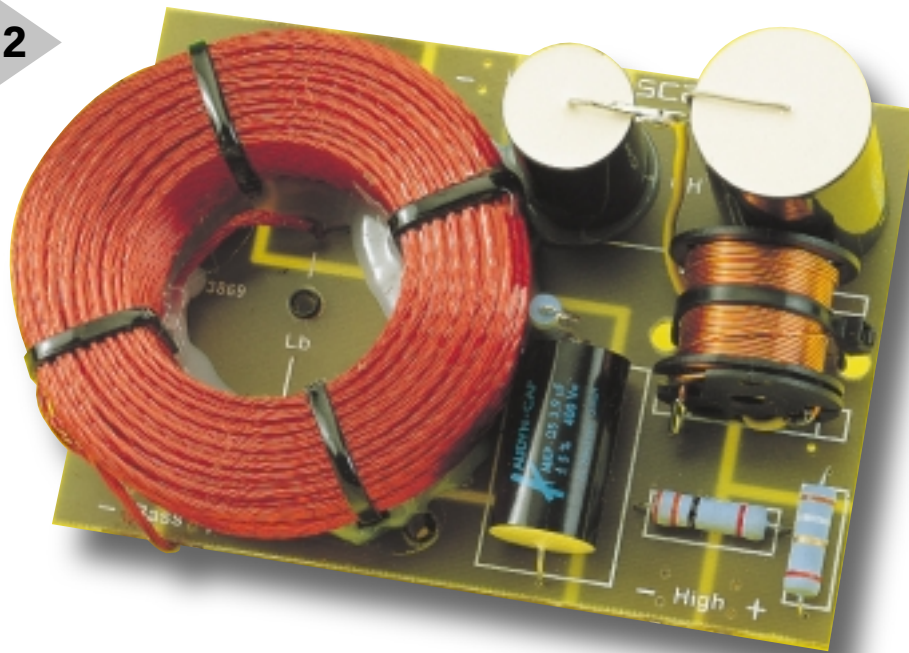


Figure 2. Photograph of a finished prototype crossover filter. Note the special air-cored inductor, L1.

tweeter by about 5 dB, which results in the sound output of the tweeter being in harmony with that of the bass/mid-range unit. This is necessary since, as usual, the sensitivities of the two drivers are dissimilar.

Capacitors C2 and C3 must be of the highest quality since this influences the performance greatly. They should, therefore, be at least metallized polypropylene (MKP, Siemens) types. According to the designer, it is better for C2 to consist of two tin foil (KPSn) types of 1 μF and 4.7 μF respectively, and C3 of two parallel-connected 10 μF MKP types in series with a 4.7 μF KPSn type. However, no differences between a prototype fitted with MKP capacitors and another fitted with KPSn capacitors were discerned during listening tests.

The overall filter is designed for a crossover frequency of 2 kHz. A prime aim of the design was to make the transit from bass/mid-range to high

frequencies seamless, in which, in our opinion, the designer has succeeded very well. A glance at the frequency response characteristic in **Figure 4** will show that the crossover point is not detectable.

Because of the small number of components, these can just be soldered together as appropriate or be housed on a general-purpose filter board, which is available from most audio/loudspeaker retail shops.

It is important to note that, as shown in Figure 1, the bass/mid-range driver and tweeter are connected to the filter in phase. Do not make a mistake in the polarity as this would seriously impair the loudspeaker's performance.

A photograph of a finished prototype of the filter is shown in **Figure 2**.

ENCLOSURE

The construction of the A4 Monitor is relatively simple: just six panels with

some essential openings fastened together — bracing panels or struts are not needed. In fact, the enclosure could readily be built with reference to **Figure 3**, were it not for a few salient details.

To start with, note that the tweeter is not mounted centrally, which, together with the rounded corners of the front panel, is imperative for obtaining the correct radiation pattern.

Further, in contrast to usual practice, the bass reflex port is at the rear of the enclosure. The port consists of a slightly conical 123 mm long PVC pipe with a diameter of about 35 mm. This pipe is commercially available — see the Components List.

Undesired panel resonances are obviated by using 22 mm thick medium-density fibreboard (MDF) for the side, top and bottom panels, and 30 mm thick MDF for the front panel. Internally, all panels are covered with 4 mm thick strips of lead sheet (expensive).

COMPONENTS LIST

Drive units:

LS1 = 15W8530K00 (Scan-Speak)
LS2 = D2904/980000 (Scan-Speak)

Components:

R1, R2 = 3.9 Ω , 4 W, low-inductance type
R3 = 33 Ω , 4 W, low-inductance type
C1 = 3.9 μF , MKP (polypropylene, Siemens)

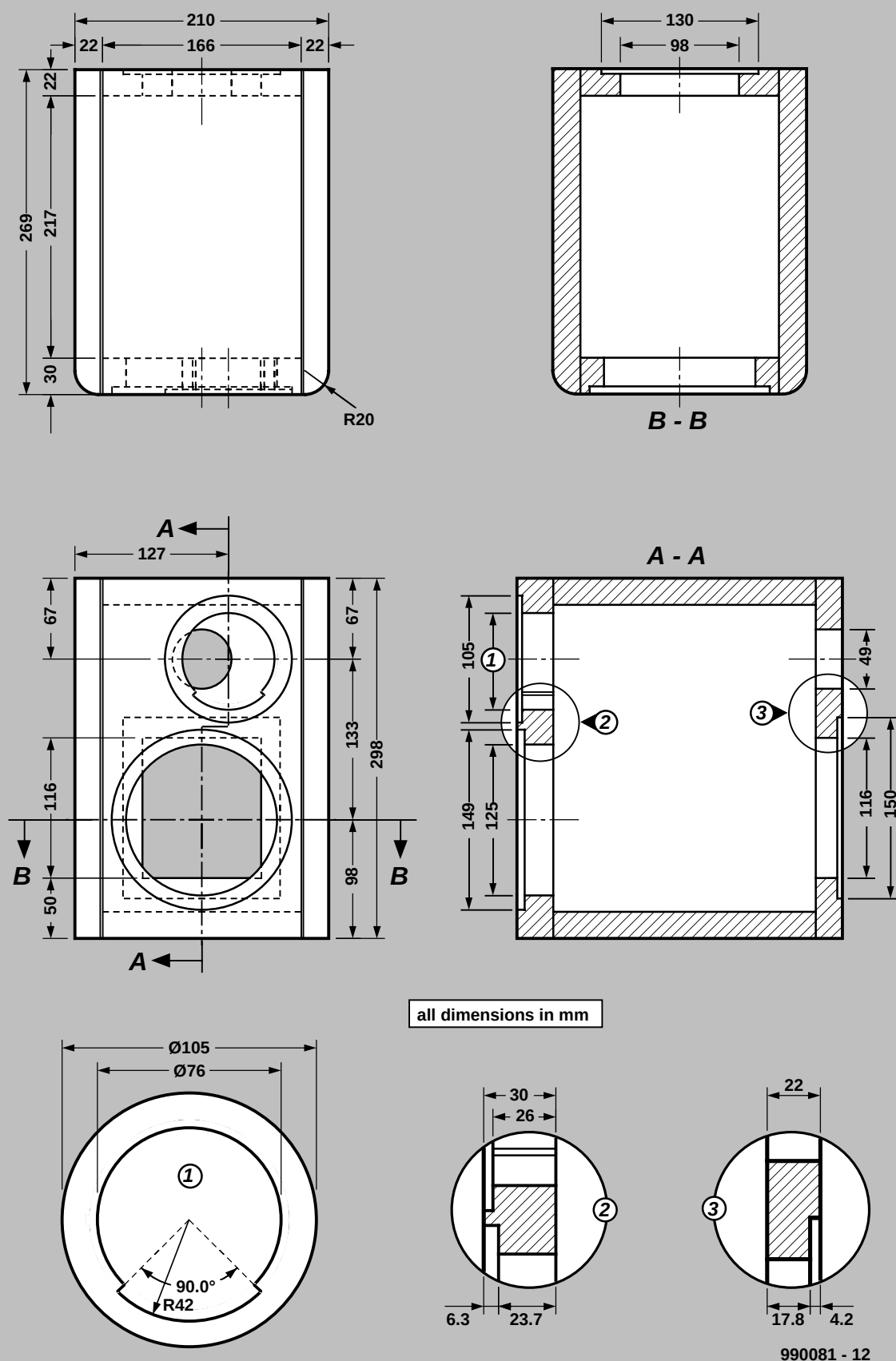
C2 = 5.6 μF , KPSn or MKP (see text)
C3 = 15 μF , KPSn or MKP (see text)
L1 = 2.2 mH, Tritac 7 $\times$ 0.50 mm
L2 = 0.39 mH, air-cored, made with 0.71 mm dia. enamelled copper wire

MDF (medium density fibreboard)

front panel: 298 $\times$ 189 $\times$ 30 mm
back panel: 298 $\times$ 189 $\times$ 22 mm
side panels: 298 $\times$ 289 $\times$ 22 mm (2 off)
top and bottom panel: 217 $\times$ 266 $\times$ 22 mm (2 off)

Miscellaneous:

Terminal board, e.g., Intertechnik Type T150/130
Bass reflex port: Intertechnik Type HP35 (dia. 35 mm; length 125 mm)
Lead sheet or bituminous impregnated felt: 3 strips 25 $\times$ 33 cm (4 mm thick)
Latex foam wadding: as required (42 mm thick)



sive!) or bituminous impregnated felt.

Provided all the carpentry work is first class, the enclosure remains stock-still.

As shown in Figure 3, the drivers are flush-mounted — if this is not done, the frequency response will

have a few dips. In the prototype, even the terminal boards are flush-

mounted, but that is of cosmetic interest only.

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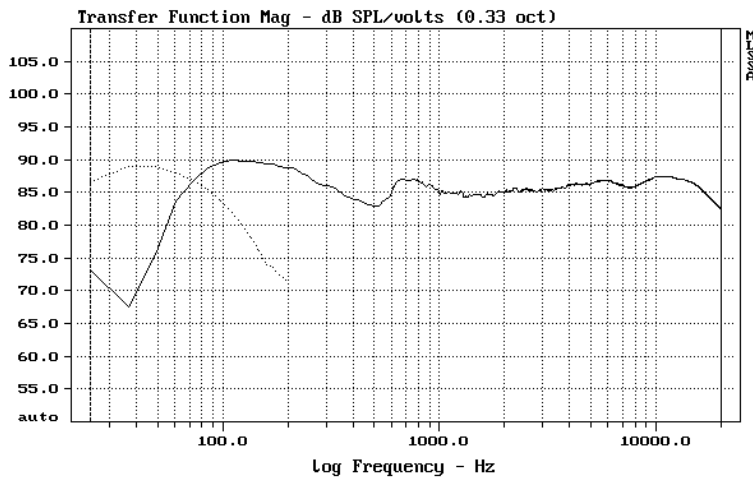


Figure 4. The frequency vs sound pressure level (SPL) characteristic shows an exemplary response.

Although the Components List specifies a heavy-duty terminal board with dual connections from Intertechnik, there are other boards available that are smaller and can still cope with heavy-duty loudspeaker cable. Moreover, there are boards with two terminals and others with four terminals – the choice depends on whether bi-wiring will be used or not.

Acoustic damping is obtained by covering the lead sheet or bituminous felt with latex foam wadding. It is, of course, essential that this material is cut carefully around the various openings, so that it does not get into the way when the drivers or reflex port are being fitted.

The crossover filter is best fitted on the inside bottom panel. Good-quality loudspeaker cable should be used for interwiring the units.

Finishing the exterior of the enclosure is a matter of individual taste. Currently, a lac-

quer finish is very popular, but veneer remains

the choice of many. Lacquering is best carried out by a car body workshop; this will cost a few bob, but the result is good looking and durable.

BENCH TEST

So as to obtain a good and faithful impression of the performance of the A4 Monitor, testing consisted of an introductory listening test, followed by a bench test, and finally an extensive listening test.

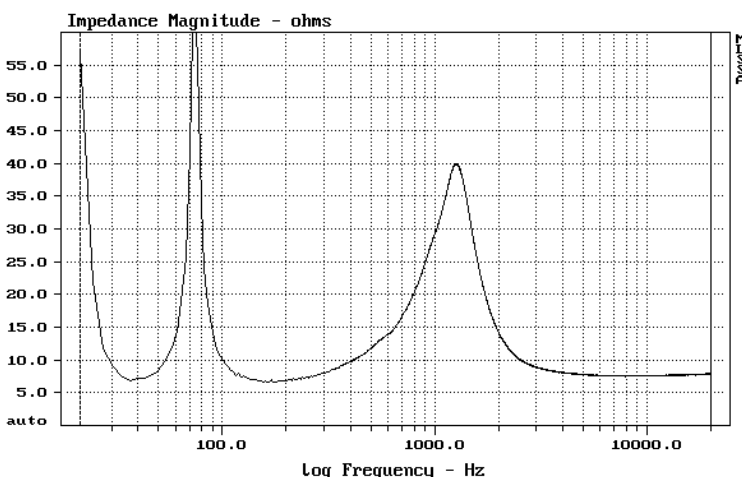
The bench test results and listening tests were in good harmony and yielded no unexpected surprises. All the same, the listening tests exceeded the expectations engendered by the bench test results, that is, the loud-

speaker sounds better than the measurements indicate.

The frequency response characteristic is

Figure 5. The frequency vs impedance characteristic of the loudspeaker shows that the impedance does not drop below 7 Ω . The dip at around 40 Hz corresponds to the tuning of the bass reflex port.

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shown in Figure 4. The generally smooth and flat response with a slight emphasis around 100 Hz does not call for much comment. There is a slight hump of 1.5 dB at about 750 Hz, preceded by a slight dip at about 500 Hz. These tiny blemishes do not detract from the practical performance. They are certainly not caused by the bass/mid-range driver, because the response of this is as straight as a pencil. In fact, they are caused by the small dimensions of the front panel as is the case with most small enclosures.

The response shown by the dotted curve in Figure 4 was measured directly in front of the bass reflex port. The port is tuned to 40 Hz, which is more clearly shown by the impedance characteristic in Figure 5.

The characteristic in Figure 5 also shows that the impedance does not drop below about 7 Ω , which means that the loudspeaker can be driven by virtually any suitable power amplifier. It is advisable, however, to use an amplifier that has a good power reserve, because the sensitivity of the loudspeaker is rather low: about 85.5 dB/W at 1 m.

LISTENING TEST

Although bench testing is important, a loudspeaker's performance can be judged properly only from an extensive listening test.

Although the A4 Monitor is small and inconspicuous, it produces a remarkably open and faithful sound. Good live recordings are particularly well reproduced. The reproduction of sound details in the middle and high ranges is almost reminiscent of an electrostatic unit. Bass performance is dry and taut and extends further down than expected. The -3 dB point is at around 40 Hz.

As expected of a quality loudspeaker, the A4 Monitor has no preference for any kind of music: classical music, jazz, and popular music are reproduced equally well: smoothly and in a neutral manner. The characteristic voices of Luciano Pavarotti, Lou Reed, Ella Fitzgerald, and Sarah Brightman, are reproduced as faithfully as the violin of Itzhak Perlman, the clarinet of Benny Goodman, and the guitar of John Williams.

In short, the A4 Monitor is one of those rare loudspeakers that quickly makes you forget that you are testing and gets you wholly absorbed in the music.

Nevertheless, it must be borne in mind that a small loudspeaker, even one as good as the A4 Monitor, has certain limitations at low frequencies. Yet, the A4 does not emphasize these — they only become apparent when a direct comparison is made with a large loudspeaker. Even then, a loud-

The drivers

The drive units used in the A4 Monitor are products of the Danish company Scan-Speak. This company was an independent manufacturer until some years ago when it was acquired by Vifa — it is now the high-end branch of that organization. Most of Scan-Speak's drivers are hand-made, high-quality cone and dome models. The Type D2905/990000 tweeter ('Revelator'), which has been in production since the 1980s, has acquired an enviable reputation throughout the world and is generally considered to be one of the best dome tweeters on the market.

The chassis of both drive units used in the A4 Monitor is relatively new. The bass/mid-range unit is also called 'Revelator' by the manufacturer, which may be seen as an indication of its high quality.

The bass/mid-range driver has a frame designed for optimum air throughput and an exceptionally long travel of the voice coil. Because of the absence of resonances, excellent damping of the reinforced paper diaphragm, and the linearity of the cone suspension, the unit offers virtually unequalled faithful reproduction and dynamic performance for its size.

The tweeter represents a change of direction at Scan-Speak: until now all their tweeters had a textile diaphragm, but the new one used in the A4 Monitor has an aluminium dome.

Any dome has a series of dips (nulls) in its pressure response at frequencies where the path difference between the apex and the rim is a multiple of $\lambda/2$ of that frequency in air. A phase difference ensues near these nulls which causes the axial output to fall gently towards the null.

The frequency, f_n , at which the null occurs is a function of the height, h , of the dome. In a 28 mm aluminium dome ($h = 5$ mm),

$$f_n = c/\lambda = 345/5 \times 10^{-3} = 69 \text{ kHz}$$

so that the first dip occurs at 34.5 kHz. In a dome unit that is driven by a speech coil of the same diameter attached to the rim, the first breakup resonance occurs near or just before the first phase null, that is, here, 34.5 kHz, which is well above audibility.

The tweeter has a low resonant frequency (500 Hz). Its reproduction of the highest frequencies is linearized by a special singly suspended diffuser. Its sound is remarkably open, clean and well detailed.



speaker with a volume ten times greater than that of the A4 Monitor was needed to show up these low-frequency differences.

Since the bass reflex vent is at the rear of the enclosure, the loudspeaker must, of course, not be placed directly against a wall. Even so, it was felt during the test that placing the Monitor close to a wall gave better results than with the unit well away from it. This is because that position gives that

little extra warmth at low frequencies which is missing when the loudspeaker is well away from a wall. In the latter case, the A4 Monitor sounds rather more clinical.

More information on the drive units and filters from

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Fax: 01455 286605

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Also note Wilmslow Audio's special offer for the drive units, as advertised elsewhere in this issue.

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